PATTERNS OF DISTRIBUTION OF DIATOM ASSEMBLAGES IN PEATLANDS ECOSYSTEM ON VRANICA MOUNTAIN (BOSNIA AND HERZEGOVINA)

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Summary

The field research for this study was carried out during the autumn season in 2018 at three well developed peatland ecosystems on Vranica mountain. Collection of diatom samples was carried out by squeezing *Sphagnum* moss. After squeezing, collected material was fixed with 4% solution of formalin. Laboratory processing of diatom samples was carried out applying methods used by Hustedt (1930). A total of 78 taxa belonging to 33 genera were determined in the collected samples. Genera with the highest number of species were *Eunotia* (14), *Pinnularia* (11), *Gomphonema* (5) and *Neidium* (5). Altogether 77 diatom taxa mostly belonging to pennate diatoms were found. The only centric species, *Aulacoseira alpigena* (Grunow) Krammer 1991, appeared in one sample only. The most common species were *Encyonema perpusillum*, *Pinnularia borealis*, *Frustulia crassinervia*, *Pinnularia rupestris*, *Eunotia paludosa*, *Pinnularia microstauron*, *Pinnularia perirrorata*, *Eunotia valida*, *Tabellaria ventricosa*, *Pinnularia subcapitata* var. *elongata*. This study showed the presence of the large number of rare and endangered species in the peatland ecosystems on Vranica mountain, but also pronounced negative anthropogenic influences. In order to protect these unique and extremely valuable ecosystems in the future, certain restoration and conservation actions should be undertaken. These activities should be seen in the establishment of long-term monitoring and prevention of further degradation of peatland ecosystems through more active and stronger protection.

Key words: *diatoms, peatlands, anthropogenic influences, restoration, conservation*

INTRODUCTION

Peatlands are considered both important habitats and biodiversity hotspots worldwide (Szigyártó *et al*., 2017). These types of ecosystems are characterized by extreme environmental conditions not found in other wetland ecosystems. Cold, anaerobic, and nutrient-poor conditions limit decay of organic matter. Because the rate of organic matter accumulation exceeds the rate of decomposition, peatlands are autogenic or "*self-creating*" habitats (Krivograd-Klemenčić and Vrhovšek, 2003; Bahls *et al*., 2013). With climate change, studies of peatlands are now more important than ever owing to the vast quantities of carbon stored within these regions and their future

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role as net carbon sinks (Roulet, 2000; Waddington *et al*., 2009; Hargan *et al*., 2015). Peatlands are important to the global carbon cycle because they store a large component of the world's soil carbon stocks (Gorham, 1991; Brugham and Swin, 2000) and supply most of the dissolved organic carbon (DOC) entering in boreal lakes and rivers (Wyatt *et al*., 2012). They are also major sinks for atmospheric carbon and may disappear with future climatic warming (Gorham, 1991; Janssens *et al*., 1992; Brugham and Swain, 2000). However, many peatlands have been destroyed by human activities, such as peat extraction, land reclamation or drainage of ground water for development purposes (Rauch *et al*., 2006). An ecosystem approach based both on biological and hydrological studies is necessary for the conservation of these landscapes (Klemenčić *et al*., 2010). Peatlands are important ecosystems for the conservation of biodiversity in Europe (Klemenčić *et al*., 2010). The necessity of biodiversity studies in peatlands today is underlined by the fact that these small, oligotrophic and mountain habitats of glacial relic origin are very sensitive to anthropogenic impacts and have become threatened in the last decades (Kapetanović *et al*., 2011). Mountain peatlands often support distinctive ecological communities due to their unique physical and chemical characteristics (Liu *et al*., 2011). The colonisation by specifically adapted organisms makes them very important habitats for nature conservation (Cantonati *et al*., 2011). Algae play vital roles in biodiversity conservation and the biogeochemical cycles of peatlands, they have been less investigated than peatland microorganisms (e.g. *Sphagnum* and vascular plants) (Poulícková *et al*., 2003; Cantonati *et al*., 2011; Rydin and Jeglum, 2013; Chen *et al*., 2016 in Bai *et al*., 2018). In peatlands, diversity of some groups of algae (desmids) can be very high and many taxa appear to be restricted to these habitats (Klemenčić *et al*., 2010). Diatoms are currently recognized as dominant components of the algal flora in ombrotrophic and minerotrophic mires (Nováková, 2002; Negro *et al*., 2003) and can be used as good indicators of the quality status of pristine areas (Kapetanović *et al*., 2011). Peatland ecosystems in territory of Bosnia and Herzegovina occupy a very small area. Since, they represent the remains of vegetation from age much colder climates, they are classified as a glacial relict. According to world distribution, peatland ecosystems in Bosnia and Herzegovina are locate on the southern border of their area. This distribution indicates their high isolation and vulnerability (Barudanović *et al*., 2017). Study on algae from peatland ecosystems in Bosnia and Herzegovina is scarce. So far study has been carried out in the area of Zvijezda mountain (Kapetanović *et al*. 2011) and partly in the Vranica mountain (Barudanović *et al*., 2017). Considering on conducted research, it can be concluded that the peatland ecosystems in the area of Bosnia and Herzegovina are unique ecosystems and with great conservation potential. Thus, authors Kapetanović *et al*. (2011) in peatland ecosystems which are located in Protected landscape of Bijambare (Zvijezda mountain) described two new diatom species for science as follows: *Sellaphora bosniaca* Kapetanović and Jahn sp. nov. and *Sellaphora hafnerae* Kapetanović and Jahn sp. nov. In addition, a large number of new species for the

flora of algae of Bosnia and Herzegovina has been identified (Kapetanović *et al*., 2011).
The main aim of this paper was to investigate the patterns of diatom assemblages in peatland ecosystems on Vranica mountain. Special attention of this paper was pointed on rare and endangered species of diatom which occupied this very unique habitat types.

MATERIALS AND METHODS

The field research was carried out during the autumn season in 2018 at three well developed peatland ecosystems on Vranica mountain. During the investigated period, a total of 11 samples of phytobenthos were collected. Studied sites are indicated by symbols **G1** (S1, S2, S3, S4), **G2** (S5, S6) and **G3** (S7, S8, S9, S10, S11). Studied peatland ecosystems are located at different altitudes and they are under different anthropogenic influences. The main characteristics of investigated peatlands on Vranica mountain are shown in table (Tab. 1).

Tab. 1. The main characteristics of investigated peatlands on Vranica mountain

Group	Date	Altitude [m]	Coordinate [N]	Coordinate [E]	Anthropogenic disturbance
1 / G1	20.10.2018.	1632	43.95754	17.75866	High
2 / G1	20.10.2018.	1634	43.95750	17.75868	High
3 / G1	20.10.2018.	1630	43.95741	17.75877	High
4 / G1	20.10.2018.	1634	43.95742	17.75880	Moderate
5 / G2	15.09.2018.	1714	43.95194	17.75807	Moderate
6 / G2	15.09.2018.	1714	43.95192	17.75827	Moderate
7 / G3	15.09.2018.	1755	43.95135	17.76056	Low
8 / G3	15.09.2018.	1755	43.95134	17.76057	Low
9 / G3	15.09.2018.	1755	43.95133	17.76061	Low
10 / G3	15.09.2018.	1755	43.95131	17.76065	Low
11 / G3	27.10.2018.	1761	43.95137	17.76060	Low

According to topography, studied peatland ecosystems belongs to the continental Dinarides (Redžić, 2007). It is well known that Vranica mountain is rich in numerous springs, brooks, and small rivers, which are active throughout the year, and they determine specific hydrological regime of this area. The glacier Prokoško lake at the 1635 meter a.s.l. gives the subalpine belt a particular ecological value (Spahić, 2001; Redžić, 2007). Vranica mountain has a very heterogeneous geology and petrography. Various eruptive rocks and crystal shale’s, feldspars, muscovite and biotite play the dominant role here. All three parts of Devon: lower, middle, and upper, have been found in this area (Redžić, 2007). According to Redžić (2007) plant coverage of this area could be divided into 28 classes, 44 orders, 73 alliances and 165 communities of the level of association. Very sensitive vegetation from the classes *Scheuzerio-Caricetea fuscae* and *Montio-Cardaminetea* has been developed on this area, including peatland ecosystems. Despite their relatively small areas, the vegetation from these two classes is very diverse, which has been confirmed by comparative investigations carried out in the other parts of Europe (Lakušić, 1966; Horvat *et al*., 1974; Zechmeister and Mucina, 1994). Several endemic and relict communities have been recently described in these vegetation islands (Redžić, 2007). Collection of phytobenthos samples was carried out by squeezing *Sphagnum* moss. After squeezing, collected material was fixed with 4% solution of formalin. Laboratory processing of diatom samples was carried out applying methods used by Hustedt (1930). In order to obtain pure valves of diatoms, part of the obtained material was digested with sulfuric acid (H_2SO_4), potassium permanganate ($KMnO_4$) and oxalic acid ($C_2H_2O_4$). The cleaned valves of diatoms are then mounted in a Canada balsam (Mašić *et al*., 2018). Five permanent slides have been prepared for each sample and a total 300 valves were counted to asses relative abundance. Species with a content above 5% in a given assemblages were defined as abundant. All slides were scanned for taxa with low relative abundance. Light microscope observation was conducted using Best Scope 2020 microscope. Species composition and quantitative relationship of diatoms are estimated from the permanent slides under 1000x magnification. Species abundance of diatoms are estimated on a five-degree scale as follows: 1-rare (single valve or frustule), 2-sparse (up to 10% of the sample), 3-frequent (11-15% of the sample), 4-very frequent (51-75% of the sample), 5-common (in more than 75% of the sample). The identification of diatom was supported by the following reference: Cantonati *et al*. (2017). The nomenclature of diatoms is adjusted according to the following internet base: Guiry and Guiry (2020). Omnidia software (Lecointe *et al*., 1993) version 6.0.8, was used to calculate diatomaceous indices, including ecological and taxonomic data. The water quality of the peatlands was assessed based on four diatom indices as follows: IPS – Specific, pollution sensitivity Index (Coste, 1982), SLAD - Sládeček's index (Sládeček, 1986), TID - ROTT trophic index (Rott, 1999) and SID - ROTT saprobic index (Rott *et al*., 1997). Range of diatom indices varied from 1 to 20 and corresponding to the ecological statuses as follows: bad (1-4), poor (5-8), moderate (9-12), good (13-16) and very good (17-20). In order to determine variables important for number of species, i.e. determining the correlation between dependent (diversity index) and the independent variables (temperature, pH, dissolved oxygen, specific electric conductivity, turbidity, TDS) Pearson's coefficient of simple linear correlation (r) was used. Pearson's coefficient of correlation between analysed variables was tested using Student t-test at a significance level of <0.05. A univariate statistical analysis was performed using the software package PAST v.3.24 (Hammer, 2017). Species diversity in diatom assemblages was determined using Shannon (H') index (Shannon and Weaver, 1949). According to the Red List of diatoms (Lange-Bertalot and Steindorf, 1996), the threatened diatoms were attributed to the categories: threatened of extinction [1], highly endangered [2], endangered [3], at risk [G], very rare [R] and declining [V]. In order to analyse the

differentiation of individual samples collected at different peatlands on Vranica mountain, the Principal Coordinate Analysis (PCoA) was used. The ordination was conducted on the Bray-Curtis similarity matrix of species data (Legendra and Legendre, 1998; Kamberović *et al.*, 2016; Mašić *et al.*, 2018).
The data was transformed by $log_{(x+1)}$ and after standardise the matrices. Environmental variables (water temperature, pH, dissolved oxygen, specific conductance and turbidity) are presented as vectors after normalisation (Pearson's correlation). The statistical analysis with graphical interpretation were performed using the software package PRIMER v6 (Anderson *et al.*, 2008).

RESULTS

Physical and chemical parameters
A comparison of the physical and chemical parameters revealed the following: the water temperature during the investigated period varied from 7.6 to 19.0 °C. The lowest pH of the water was 4.16 while the highest pH value was 7.14. The highest concentration of dissolved oxygen in water were measured at the first site (8.27 mgl^{-1}), while the smallest value was measured at the fourth site (6.47 mgl^{-1}). Value of specific electric conductivity varied from 22.44 to 600.8 μScm^{-1}. The lowest value of turbidity was measured at the third site (1,01 NTU), while at the sixth site the highest value of turbidity was measured (868 NTU). Results of physical and chemical parameters of water at sampling sites are presented in table (Tab. 2).

Tab. 2. Results of measuring the physical and chemical parameters of the water

Group	Date	T1 [°C]	pH	DO [mgl^{-1}]	SC [μScm^{-1}]	T2 [NTU]	TDS [ppm]
1 / G1	20.10.2018.	9.10	7.11	8.27	147.1	68.30	36.00
2 / G1	20.10.2018.	9.10	7.14	7.28	171.4	8.58	133.0
3 / G1	20.10.2018.	8.20	7.06	7.99	122.8	1.01	121.0
4 / G1	20.10.2018.	8.00	5.17	6.47	170.3	278	N/a
5 / G2	15.09.2018.	N/a	N/a	N/a	N/a	N/a	N/a
6 / G2	15.09.2018.	17.5	4.16	7.28	600.8	868	495.0
7 / G3	15.09.2018.	19.0	5.29	6.92	50.52	620	121.0
8 / G3	15.09.2018.	18.3	5.47	7.00	43.09	73.00	46.00
9 / G3	15.09.2018.	18.3	5.67	7.00	43.09	617	43.00
10 / G3	15.09.2018.	16.0	5.75	7.82	33.74	588	38.00
11 / G3	27.10.2018.	7.60	5.93	7.69	22.44	20.00	47.00

Correlation between diversity index and physical and chemical parameters of water
Diversity index (H') are in correlation with water temperature, dissolved oxygen, specific electroconductivity and pH, while turbidity and TDS are slightly correlated with diversity index. High value of Pearson's correlation coefficient obtained between

diversity index and water temperature (r=-0.7203*; p<0.05) and diversity index and dissolved oxygen (r=0.7099*; p<0.05). These correlations are significant at the p<0.05. Moderate and positive correlation obtained between diversity index and specific electroconductivity (r=0.3982) and between diversity index and pH (r=0.3814). Week values of Pearson's correlation coefficient are obtained between diversity index and turbidity (r=-0.3082) and between diversity index and TDS (r=0.2645). Moderate and week values of Pearson's correlation coefficient is not significant at the p<0.05 level.

Diversity of diatoms in the studied peatlands on Vranica mountain
A total of 78 taxa belonging to 33 genera were determined in the collected samples. Genera with the highest number of species were *Eunotia* (14), *Pinnularia* (11), *Gomphonema* (5) and *Neidium* (5). Altogether 77 diatom taxa mostly belonging to pennate diatoms were found. The only centric species, *Aulacoseira alpigena*, appeared in one sample only. The most common species were *Encyonema perpusillum, Pinnularia borealis, Frustulia crassinervia, Pinnularia rupestris, Eunotia paludosa, Pinnularia microstauron, Pinnularia perirrorata, Eunotia valida, Tabellaria ventricosa, Pinnularia subcapitata* var. *elongata*.

Diversity of rare and endangered diatom taxa
According to the Red List of freshwater diatoms (Lange-Bertalot and Steindorf, 1996) about 44 taxa are cited under various categories: threatened of extinction (1 taxa), highly endangered (1 taxa), very rare (1 taxa), endangered (5 taxa), at risk (13 taxa) and declining (23 taxa). Very rare diatom taxa which inhabit peatlands on Vranica mountain were *Eunotia triodon* (1), *Eunotia tetraodon* (2), *Epithemia goeppertiana* (R), *Encyonema vulgare* (G), *Eunotia nymanniana* (G), *Neidium bisulcatum* (G), *Neidium bisulcatum* var. *subampliatum* (G) and *Placoneis ignorata* (G). In total 23 diatom taxa whose number decreased due to the degradation of their natural habitats were found in the studied peatlands as follows: *Adlafia bryophila, Chamaepinnularia mediocris, Cymbella aspera, Cymbella neolanceolata, Cymbopleura amphicephala, Cymbopleura austriaca, Diploneis krammeri, Eunotia paludosa, Eunotia rhomboidea, Eunotia tenella, Fragilaria virescens, Frustulia crassinervia, Frustulia saxonica, Gomphonema exilissimum, Gomphonema hebridense, Kobayasiella parasubtilissima, Neidium affine, Neidium ampliatum, Nitzschia sinuata, Pinnularia microstauron, Psammothidium bioretii, Psammothidium subatomoides and Surirella spiralis.*

Differentiation of diatom assemblages in the studied peatland ecosystems
In order to differentiate the composition of diatom assemblages in relation to the gradient of the measured physical and chemical parameters, the method of PCoA analysis was used. Results of PCoA differentiation of the analysed diatom assemblages were shown in Figure (Fig.1). The first PCoA axis explained 54,9% total variation, while the second PCoA axis explained 15,7% of the total variation. PCoA

analysis clearly shows differentiation of studied phytobenthos samples on three groups. Differentiated groups are located at different altitudes and they are under different anthropogenic influences. Samples of phytobenthos which are distributed on the right side of the chart are located at altitude over 1700 meters, while samples of phytobenthos which are distributed on left side of the chart are located at altitude about 1630 meters. Peatlands which are located on high altitude are under moderate or low anthropogenic disturbance, while peatlands which are located on the low altitude are under strong anthropogenic disturbance. Peatland ecosystems within the first group are reduced and small island of *Sphagnum* moss build this habitat.

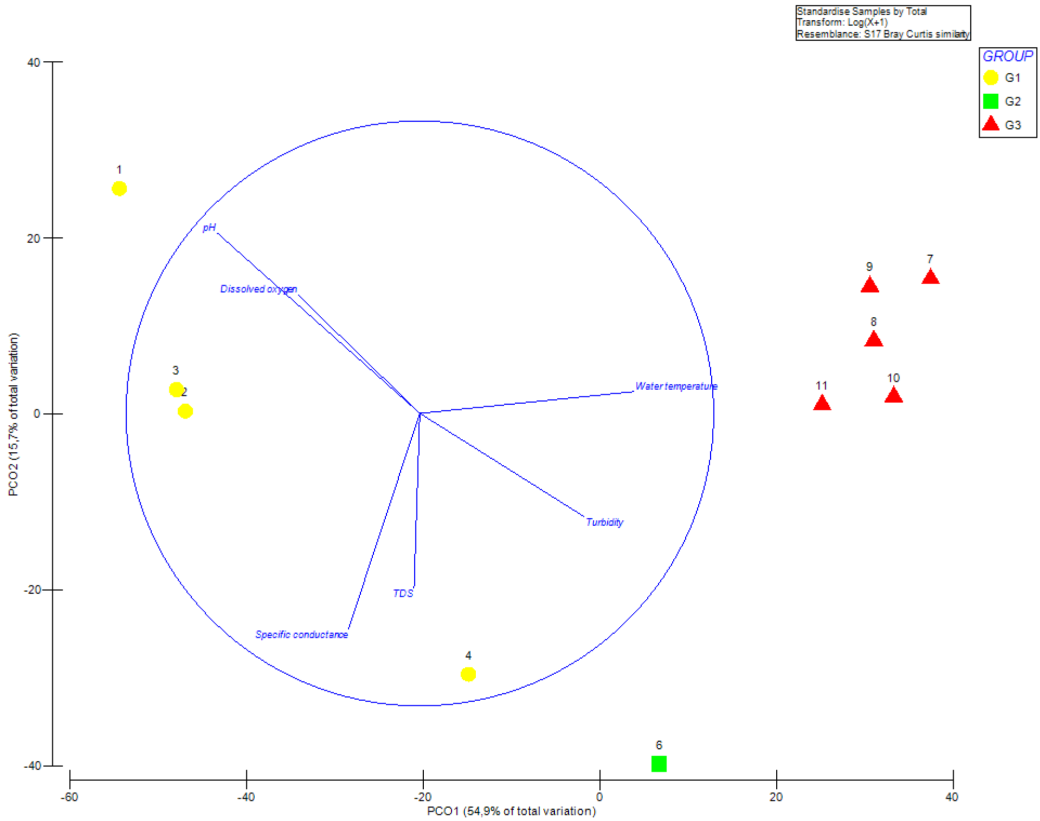

Fig. 1. PCoA differentiation of the analysed diatom assemblages

Strong anthropogenic influences reduced this type of habitat in lower altitude. In contrast peatland ecosystems at higher altitudes are in better condition and under minor anthropogenic influences. Upon the diversity level analysis, it may be concluded that the diatom samples collected from peatlands on low altitude have high diversity level, while diatom samples collected from peatlands on high altitude have something lower diversity level. Peatlands from the first group (G1) are under strong anthropogenic influences which are suitable habitat for diatoms with wide ecological valence, while peatlands which are developed in high altitude are suitable for diatoms with narrow ecological valence. On the first PCoA axis, sample from the group one (G1) of peatland were distributed, while on the second PCoA axis, sample from the group two (G2) and group three (G3) of peatlands were distributed. Samples from the first PCoA axis were characterised with higher values of pH, dissolved oxygen, specific conductance and TDS, while samples from second PCoA axis were characterised with higher values of turbidity and water temperature.

Results of indicator values of diatoms
Indicator values were used (Van Dam *et al*., 1994) for the purpose of understanding the complex environmental conditions.
A comparison between the spectrum of indicator values of the three peatland ecosystems reveals important differences, such as:

1) Peatland ecosystems which belong to the first and second groups were inhabit with neutrophilic taxa, while peatland which belong to the third group were inhabit mainly with acidophilic taxa.
2) In relation to the salinity, peatlands from first and second groups were inhabited by oligohalophobous taxa, while peatland from the third group inhabit mostly halophobous taxa.
3) All investigated peatland ecosystems on Vranica mountain in relation to saprobity were inhabited with oligosaprobic species.
4) In relation to the trophic state studied, peatlands from the first and second groups were inhabited with mesotrophic, while peatland from third group were inhabited with oligomesotrophic taxa.
5) Similar indicator values were observed in terms of humidity, nitrogen uptake and oxygen demand. Increased values were established in the first and second group of peatlands, while within third group there was somewhat lower values of analysed indicator values.

Ecological status of investigated peatland ecosystems according to diatom indices
Values of IPS diatom index varied from 17.5 (1) to 19.6 (11). According to analysed diatom index all studied sites have very good ecological status. Saprobes index at sites 1, 2, 3, 5 and 6 indicate good, while on the other studied sites indicate very good ecological status. Trophic index at sites 1, 2 and 3 indicate good, while at the others analysed sites indicate very good ecological status. High values of Saprobes index indicate a very good ecological status of peatland ecosystems on Vranica mountain.

DISCUSSION

As ecosystems with a relict and island character, mountain peatlands belong to the most valuable and threatened biotopes in Central Europe (Štěpánková *et al*., 2012). Peatlands possess important ecological properties, far in excess of their spatial extent. Moreover, their territory is expected to diminish in response to drying up related to anthropogenic and climatic factors. Nutrient-poor peat bogs are one of the most important centres for maintaining the biodiversity of sensitive to eutrophication algae but unfortunately also one of the most threatened oligotrophic biotopes in Europe (Buczkó and Wojtal, 2005). The *Sphagnum* bogs and related mire communities represent one of the major vegetation types beside forests and grasslands at higher latitudes of the Northern hemisphere and they are, even though not that characteristic, abundant in the cooler and wet temperate regions (Klemenčič *et al*., 2010). On the territory of Bosnia and Herzegovina peatland ecosystems are located on the southern border of their areal (Barudanović *et al*., 2017). The first systematic research of peatland ecosystems in Bosnia and Herzegovina was carried out at the end of the 20th century (Lakušić *et al*., 1991 in Barudanović *et al*., 2017). According to Lakušić *et al*. (1991) this extraordinary type of ecosystem present refugium for large number of plant and animal species. Although peatland ecosystems occupy small areas, they have a great conservation value due to the unique living world. From the viewpoint of nature conservation, each of these more or less isolated biotopes have a great importance, namely to preservation of ecologically distinctive organisms and communities and, in addition, as a place with potential for further evolution of this diversity (Štěpánková *et al*., 2012). A few algological studies conducted previously on this area concerned different algae groups (Kapetanović and Hafner, 2007; Barudanović *et al*., 2017). According to current study in total 78 diatom taxa from 33 genera were found in peatland ecosystems. The largest number of diatom taxa belong to the genera *Eunotia* (14), *Pinnularia* (11), *Gomphonema* (5) and *Neidium* (5). According to Red List (Lange-Bertalo and Steindorf, 1996) in total 44 diatom taxa (56,41%) has a certain degree of vulnerability. The most vulnerable taxa found in peatland ecosystems on Vranica mountain were: *Eunotia triodon* (1), *Eunotia tetraodon* (2), *Epithemia goeppertiana* (R), *Encyonema vulgare* (G), *Eunotia nymanniana* (G), *Neidium bisulcatum* (G), *Neidium bisulcatum* var. *subampliatum* (G) and *Placoneis ignorata* (G). This study was shown that peatlands which are located at the higher altitude have a smaller diversity index, unlike peatlands which are located at the lower altitude. The main reason for high diversity index is related with partially changed ecological conditions which are results by human influences and by the presence of eurivalent taxa. According to PCoA, first axis determined the increased values of pH, dissolved oxygen, specific electric conductivity and TDS, while the second PCoA axis determined the increased values of temperature and turbidity of water. Significant correlation was determined between the diversity index and water temperature ($r=-0.7203^*$; $p<0.05$), and between diversity index and dissolved oxygen in water ($r=0.7099^*$; $p<0.05$). Diatoms indices (IPS, Sla, TID and SID) were showed a good ecological status of peatland ecosystems on Vranica mountain. Ecological indices (Van Dam *et al*., 1994) confirm the characteristic ecological status of peatland ecosystems, which is reflected in the presence of acidophilic, oligosaprobic and oligomesotrophic species. PCoA analysis clearly distinguishes sites that are under the strong anthropogenic influences, from those sites that are under poor anthropogenic influences. In order to increase the knowledge about diversity of algae communities in peatland ecosystems, obtained results from our study compared with available publications (Neustupa *et al.*, 2002; Nováková, 2002; Buczkó and Wojtal, 2005; Kapetanović and Hafner, 2007; Kulikovskiy *et al*., 2008, 2009; Klemenčič *et al*., 2010; Kapetanović *et al*., 2011; Štěpánková *et al*., 2012; Vidaković *et al*., 2016; Noga, 2019). Preliminary research of diatoms in wet habitats in the subalpine belt of Vranica mountain, by authors Kapetanović and Hafner (2007) noted a presence in total 221 diatom taxa.

The most numerous among them belong to the genera *Eunotia*, *Navicula* and *Cymbella*. Dominant diatom taxa found in all collected samples were *Caloneis silicula*, *Cymbella ventricosa*, *Diatoma mesodon*, *Diploneis ovalis*, *Pinnularia microstauron* and *Pinnularia viridis*. Research of diatoms in poor fen of Bijambare protected landscape in Bosnia and Herzegovina reveal a presence in total 126 diatom taxa (Kapetanović *et al*., 2011). Two new species for science was describe and lot of new diatom taxa for flora of algae of Bosna and Herzegovina. Genera with high number of taxa were *Pinnularia* and *Eunotia*. From the total number of identified diatoms, 95 taxon has a certain degree of vulnerability. The most abundant taxa are oligotraphentic or oligo-mesotraphentic species. It is expected that the taxa from the genera such as *Pinnularia* and *Eunotia* will be most represented, as *Pinnularia* taxa can be found in a wide range of water habitats, but are indicative for acid and oligotrophic freshwaters and *Eunotia* taxa are strong indicators for acid, fresh and oligotrophic waters rich in oxygen and poor in organic nitrogen compounds. Authors Klemenečić *et al*. (2010) investigated patterns of algae communities in peatland ecosystems. In addition to high level of algal taxa (337 taxa from ten Classis) main factors for differentiation of investigated community have been identified. CCA analysis has determined that the most important factor for distribution of diatoms and desmids was type of substrate, while other factors do not have important impact on differentiation. In peatland ecosystems which are distributed in Southwestern Serbia (Pešter Plateau), authors Vidaković *et al*. (2016) noted high diversity of diatoms. In total 250 diatom taxa belonging to the 53 genera were noted. In oligotrophic habitats located in the area of Poland, which are distributed within three national parks: the Bieszczady National Park, Magura National Park, and Roztocze National Park, 13 rare and endangered diatom taxa were recorded, which nine were new for the territory of Poland. The author Noga (2019) found the following rare and endangered species in these habitat types: *Adlafia langebertalotii*, *Caloneis undulata*, *Eunotia fennica*, *E. glacialifalsa*, *E. groenlandica*, *E. minutula*, *E. neocompacta var. neocompacta*, *E. superpaludosa*, *Fallacia sublucidula*, *Pinnularia rhombarea*, *P. similiformis*, *Placogeia gereckei* and *Sellaphora vitabunda*. Specific electric conductivity in the investigated oligotrophic habitats ranged for 78 to 530 μScm^{-1}, while the pH of water in these habitats ranged from 6.4 to 8.8. Acid pH was found only within the peatlands. The concentration of ions was low or very low, often below the level of quantification, which is characteristic for oligotrophic waters. In addition to diatom taxa, which are permanent component of peatland ecosystems, second the most important group are desmid algae. Authors Štěpánková *et al*. (2012) are during study which are carried out in eight peatlands at Jeseniky mountain found 51 desmid taxa. Most of the

identified species are oligotrophic and acidophilic. According to this study and literature data from previous studies, it can be concluded that peatland ecosystems in the area of Vranica mountain are an exceptionally suitable habitat for a large number of rare and endangered diatom taxa. More than 50% of noted diatoms found in Red List (Lange-Bertalot and Steindorf, 1996) have a certain category of vulnerability. This study showed the presence of the large number of rare and endangered species in the peatland ecosystems on Vranica mountain, but also pronounced negative anthropogenic influences.
In order to protect these unique and extremely valuable ecosystems in the future, certain restoration and conservation actions should be undertaken. These activities should be seen in the establishment of long-term monitoring and prevention of further degradation of peatland ecosystems through more active and stronger protection.

CONCLUSIONS

Comparing our findings with previous research on the composition of diatom assemblages in peatlands of Europe, the presence of common diatom taxa that represent typical indicators of acid and oligotrophic environment were shown. In addition to diatoms, it is indicative that other group of algae inhabit peatland ecosystems. Despite their small coverage, this habitat types represent a hot spot of biodiversity, not only for diatom taxa but also for other group of algae. In order to protect this habitat, it is necessary to establish a long-term monitoring of biodiversity and also state of peatland ecosystems on wide area of Vranica mountain. During the future research it is necessary to pay more attention to the mentioned habitat types, especially algae as very useful indicator organisms. In order to expand knowledge about the indicator values of algae and their role in the peatland ecosystems in Bosnia and Herzegovina it is necessary to look for new sites in which these habitats have been distributed.

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OBRASCI DISTRIBUCIJE DIJATOMEJSKIH ZAJEDNICA U EKOSISTEMIMA TRESETIŠTA NA PLANINI VRANICI (BOSNA I HERCEGOVINA)

Rezime

Terenska istraživanja za ovaj rad su provedena tokom jesenje sezone 2018. godine na tri dobro razvijena ekosistema tresetišta na planini Vranici. Prikupljanje uzoraka dijatomeja izvršeno je cijeđenjem mahovina tresetarki. Nakon cijeđenja, prikupljeni materijal je fiksiran u 4% rastvoru formalina. Laboratorijska obrada uzoraka dijatomeja je provedena prema metodi Hustedta (1930). U prikupljenim uzorcima konstatovano je ukupno 78 taksona iz 33 roda. Rodovi sa najvećim brojem vrsta su: *Eunotia* (14), *Pinnularia* (11), *Gomphonema* (5) i *Neidium* (5). Konstatovano je ukupno 77 penatnih dijatomeja. Jedina centrična dijatomeja je *Aulacoseira alpigena* (Grunow) Krammer 1991. Najčešće vrste su: *Encyonema perpusillum, Pinnularia borealis, Frustulia crassinervia, Pinnularia rupestris, Eunotia paludosa, Pinnularia microstauron, Pinnularia perirrorata, Eunotia valida, Tabellaria ventricosa, Pinnularia subcapitata* var. *elongata*. Ovom studijom je ukazano na prisustvo velikog broja rijetkih i ugroženih vrsta u ekosistemima tresetišta na planini Vranici, ali su istaknuti i negativni uticaji. U cilju zaštite ovih unikatnih i ekstremno ranjivih ekosistema u budućnosti bi trebalo poduzeti nekoliko restauracijskih i konzervacijskih aktivnosti. Ove aktivnosti se ogledaju u uspostavljanju dugoročnog monitoringa i prevenciji buduće degradacije ekosistema tresetišta kroz aktivniju i jaču zaštitu.

Ključne riječi: *dijatomeje, tresetišta, antropogeni uticaji, restauracija, konzervacija.*